GPM Data Products, Their Availability, and Production Status

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1. Background

On February 28, 2014, Japan Standard Time, the Global Precipitation Measurement (GPM) mission was launched in a picture-perfect launch activity. On March 4, 2014, the GPM Microwave Imager (GMI) was put into science observation mode. The Dual-Frequency Radar (DPR) was put in science observation mode on March 8, 2014. The Precipitation Processing System (PPS) produced products immediately upon receiving the data. Both regular science products and Near-realtime (NRT) products were produced. These were made immediately available to a group of early adopters. In mid-June 2014, GMI level-1 brightness temperature products were made publicly available. In mid-July 2014, GMI and partner-radiometer precipitation retrievals were made public. GMI public availability was several months ahead of the planned release. The DPR products became publicly available on the planned release date of September 2, 2014. Data continues to be available to any user desiring it.

2. Obtaining Access to the Data

All GPM data is publicly available via ftp with no restrictions. For statistical and IT security reasons, PPS is required to track who logs into its servers and retrieves its data. While all access is done via anonymous ftp, PPS requires people desiring the data to register an email address with PPS. This email address is then used as both the user name and the password on the anonymous ftp server in lieu of the more traditional anonymous. This allows PPS to track which users are retrieving which products and provide NASA with appropriate statistics. PPS can also provide information for IT security audits that shows the users as well as their registration. While a bit more complicated than the more normal anonymous approach, it allows more detailed tracking without interfering with user access. Via automated scripts, users can still access data without requiring any manual intervention for user name and password. The use of a .netrc file makes access simple for users.

Registration is provided via a webpage: http://registration.pps.eosdis.nasa.gov. **Figure 1** shows the data entry screen with some user information entered as an example.

Users desiring access just need to fill in the form. If they also desire access to Near-realtime (NRT), they just need to select that option. Users should only request NRT access if they really need it. Once approved, all users indicating NRT requirements will automatically be added to the NRT user list and receive updates of the NRT status.

Once the form has been submitted, the user will receive an email at the address that they registered. This email will contain a link for them to confirm the registration (**Figure 2**). Once they have confirmed the registration, access to the chosen resources is automatically available. Confirmation of successful registration is received in an email (**Figure 3**). Information can be changed once the user has registered.

Fig. 1. GPM data-user registration form

Fig. 2. An email asking for confirmation of registration

Fig. 3. An email confirming registration

3. GPM Data Products

Processing Level	Sat/Inst/Alg	Size	Latency	Key Parameters
1B	GPM/GMI	5 min	≤ 1Hr 90%	Brightness Temperature-Tb
1C	GPM/GMI	5 min	≤ 1Hr ,90%	Tb same as above(future 1C reference)
1CR	GPM/GMI	5 min	≤ 1Hr, 90%	Intercalibrated Tb with matched HF and LF pixels
2A	GPM/GMI/ GPROF	5 min	≤ 1Hr 90%	Precipitation/TPW
2A Ku	GPM/DPR/ Ku	30 min	≤ 180 min	Reflectivities/3D Precipitation
2A Ka	GPM/DPR/ Ka	30 min	≤ 180 min	Reflectivities/3D Precipitation
2A DPR	GPM/DPR	30min	≤ 180min	Dual Frequency retrievals: reflectivities/3D precipitation
2B GMI/DPR	GPM/GMI-DPR	30 min	≤ 180 min 90%	Combined GMI/DPR retrieval. 3D Precipitation
3	Merged Radiometers/IR	30 min	Early – 4 hrs Late – 8 hrs	.1 deg x .1 deg global surface precipitation. *NOT Currently Available*

Table 1. GPM near-realtime products for the core satellite and multi-satellite products

Processing Level	Sat/Inst/Alg	Size	Latency	Key Parameters
1C	Metop B/MHS,Noaa 18/MHS Noaa 19/MHS	As received	Provider dependent	Intercalibrated Tb
1C	MT/SAPHIR	As received	Provider	Intercalibrated Tb
1C	NPP/ATMS	1 Hr	Provider	Intercalibrated Tb
1C	F16/SSMIS,F17/SSMIS F18/SSMIS	As received	Provider	Intercalibrated Tb
1C	TRMM/TMI	TDRSS	<=180 min	Reference Tb
1C	GCOM-W/AMSR2	orbit	~120min	Intercalibrated Tb
2A	GPROF /MHS, SAPHIR ATMS,SSMIS, TMI, AMSR2 *MHS currently early, other sounders not available*	Same as 1C	Imager 1C+40min Sounder GPROF+60min	Precipitation/TPW/more

Table 2. GPM near-realtime products for the constellation of microwave radiometers

Processing Level	Sat/Inst/Alg	Size	Key Parameters
1B	GPM/GMI	GPM orbit(Gorbit)	Brightness Temperature-Tb
1C	GPM/GMI	Gorbit	Tb (future reference)
1CR	GPM/GMI	Gorbit	Tb with matched HF and LF footprint
2A	GPM/GMI/GPROF	Gorbit	Precipitation/TPW
2A Ku	GPM/DPR/Ku	Gorbit	Reflectivities/3D Precipitation
2A Ka	GPM/DPR/Ka	Gorbit	Reflectivities/3D Precipitation
2A DPR	GPM/DPR/	Gorbit	Dual Frequency Retrievals 3D precipitation
2B GMI/DPR	GPM/GMI-DPR	Gorbit	GMI-DPR retrieval 3D Precipitation

Table 3. GPM core-satellite research products (levels 1 and 2)

Processing Level	Sat/Inst/Alg	Size	Key Parameters
3A	GPM/GMI/GPROF	0.25 deg x 0.25 deg Daily/monthly	Precipitation
3A	GPM/DPR	0.25 deg x 0.25 deg Daily	Precipitation Ascending/Descending separate
3A	GPM/DPR	0.25 deg x 0.25 deg Monthly	Precipitation
3B combined	GPM/GMI DPR	0.25 deg x 0.25 deg Daily/monthly	Precipitation
3B Merged	Merged Radiometers	0.10 deg x 0.10 deg Half hr/monthly	Gauge adjusted global precipitation

Table 4. GPM core-satellite and multi-satellite research products (level 3)

Processing Level	Sat/Inst/Alg	Size	Key Parameters
1C	Metop B/MHS Noaa 18/MHS Noaa 19/MHS	GPM orbit (Gorbit)	Intercalibrated Tb
1C	MT/SAPHIR	Gorbit	Intercalibrated Tb
1C	NPP/ATMS	Gorbit	Intercalibrated Tb
1C	F16/SSMIS F17/SSMIS F18/SSMIS	Gorbit	Intercalibrated Tb
1C	TRMM/TMI	Gorbit	Reference Tb
1C	GCOM-W/AMSR2	Gorbit	Intercalibrated Tb
2A	GPROF/MHS SAPHIR ATMS SSMIS TMI AMSR2	Same as 1C	Precipitation/TPW
3A	All instruments with GPROF 2A	Daily monthly	0.25 deg x 0.25 deg Precipitation

Table 5. GPM constellation research products

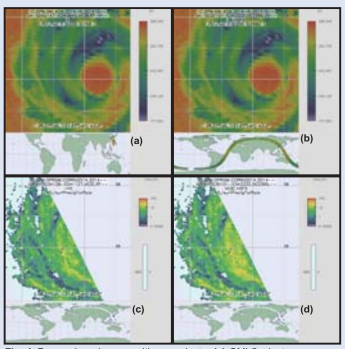


Fig. 4. Research and near-realtime products. **(a)** GMI 5-minute near-realtime product, **(b)** GMI research orbit product, **(c)** DPR+GMI combined 30-minute near-realtime product, **(d)** DPR+GMI combined research product.

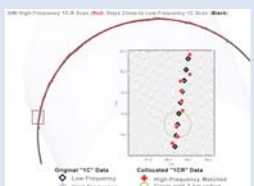


Fig. 5. Nearest neighbor matching of HF and LF GMI channels

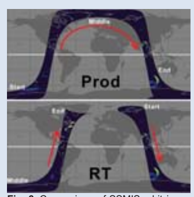


Fig. 6. Comparison of SSMIS orbit in research and near-realtime products.

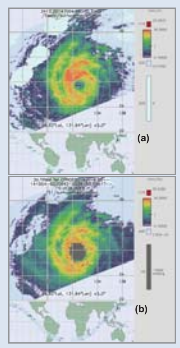


Fig. 7. TMI rain estimates for Typhoon Phanfone from (**a**) GPM GPROF2014 or (**b**) TRMM V7 2A12.

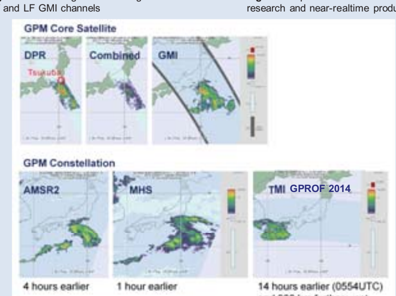


Fig. 8. GPM precipitation retrievals.

PPS produces two different types of products. The NRT data has latency requirements (**Tables 1 and 2**). The standard science research products are produced and made available as all required input and ancillary data is received (**Tables 3, 4, 5**). Sometimes the latency of ancillary products adds greatly to the latency of the standard research products. Tables 1 to 5 provide an overview of both types of products.

NRT products, except for ATMS NRT products, remain in the granule configuration received from the partner. So both the size, the orbit determination, and the availability of partner radiometer (GPM constellation radiometers) are as the partner provided them. In the case of NPP ATMS, however, an hourly product is produced in NRT.

In standard research products, all swath products are orbital—based on the GPM orbit definition. PPS re-orbitizes partner level 1B radiometer data into the GPM-defined orbit (from southernmost point of orbit to southernmost point).

The differences in this granular size and configuration can be seen in **Figure 4**. In this figure, the production granule is seen to contain a full orbit, while the NRT granule contains a partial orbit of either 5 minutes (GMI) or 30 minutes (radar) of observations.

Because of user requests and algorithm developer needs, PPS developed a GMI 1C product that co-registers (using a nearest-neighbor approach) the pixels of the GMI low-frequency channels and the GMI high-frequency channels. This co-registered product is labeled with the data type of "1CR." **Figure 5** illustrates the nearest-neighbor approach used to match the high-frequency (HF) and the low-frequency (LF) pixels in the 1CR product. **Figure 6** shows the difference between an original SSMIS orbit, as used in the NRT products, and the GPM re-orbitized orbit as used in the standard research products.

Plans call for TRMM data to be reprocessed in the future using GPM algorithms. However, as a first step, the GPM GPROF2014 algorithm is used to retrieve precipitation from TRMM data. **Figure 7** shows the results of a GPM GPROF2014 retrieval of TMI and a TRMM V7 (GPROF2010v1) 2A12 retrieval.

Although it is early in the mission and the data products are only in the initial state, there is generally good agreement among the products. GMI precipitation retrievals are not yet based on a GPM radiometer/radar physical database but instead upon an at-launch database. In addition, the retrieval over land is new to this approach (not like that used in TRMM) and is, like the retrieval over the ocean, database driven. In spite of this early state, reasonable retrievals are being made. For example, **Figure 8** shows GPM estimates of rainfall from both GMI and radar over Tskuba Japan at 2038 UTC on 14 May 2014.

GMI Improvement Activities

<u>Sample range changes</u>

- Hot and cold sample ranges updated after launch.
- Reduced NEDT of hot and cold load (especially cold load).
- For example, before changes NEDT for 23GHz V was 1K, and after changes: ~0.3K.

<u>Cold vector updates and moon correction</u> **(Figure 9)**

- Vector updates based on new sample range.
- Allowed full application of moon intrusion correction.
  - Angle between the cold vectors and moon vectors in GMI coordinate system.
  - If angle less than 6 deg, sample is flagged for intrusion and not used for calibration.

<u>Adjusted warm intrusion into cold load (RFI)</u> **(Figure 10)**

- Done by both minimum and mean check: Min check tends to underflag; mean+iteration overflags.
- First iteration flags pixel if both methods flagged it.
- If mean check method flagged sample and minimum check flagged a sample within a 15 x 51 pixel window, the sample is flagged.
- Flagged samples excluded from calibration.

<u>During deep space calibration, detected magnetic field anomalies</u>

- Matched to satellite moving through the earth's magnetic field (correlation higher than 96%).
- Instrument susceptibility to magnetic changes.
- The magnetic correction use the earth magnetic field and a set of coefficients derived by Ball/RSS plus an along-scan correction for each sample.
- An along-scan correction applied after APC (Ta→Tb).

<u>Non-linearity and diode excess temperature</u>

- Non-linearity and diode excess temperature look-up tables are updated based on the 4-point calibration.
- The updates of non-linearity have a limited influence on Ta/Tb retrieval (< 0.2 K).
- The updates of excess temperature influence only back-up algorithm when the hot load information is lost for a substantial period (> 400 scans).

A subtle effect on Tb was discovered that pointed to changes as the satellite moved through the earth's magnetic field **(Figure 11)**. Ball Aerospace did a superb job of identifying these effects and of developing an approach to correcting them. These corrections have been included in the current version of GM Level 1B and Level 1C products. Figure 11 shows the effect before correction and after correction for the LF GMI channels (blue curve before correction and red curve after correction).

Radar L2 Improvement Activities

After the launch of GPM-core satellite and the activation of both Ku and Ka-band radars, there were several improvements made in the Level-2 retrieval algorithms. One of the key improvements was the development of a routine to address the Ku side-lobe clutter issue. These improvements include:

- Compensation in measured reflectivity for side-lobe and main-lobe clutter in the Ku-band radar resulting in improved precipitation detection and clutter screening.
  - Initial corrections used average statistics of clutter intensity.
  - Public release uses scan-by-scan corrections based on sigma-0 statistics.
- Improvement of surface clutter detection and assignment of clutter-free range bins.
- Saturation of sigma-0 at Ku-band identified in Level-2 output and compensated for on-board.
- Tuning of precipitation classification algorithms for single and dual-frequency retrievals.
- Level-3 output changed to include statistics of narrow swath DPR dual-frequency method retrievals in addition to single-frequency Ku and Ka statistics.

4. Improvement Activities Prior to Public Release

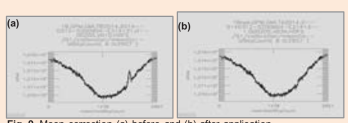


Fig. 9. Moon correction (a) before and (b) after application.

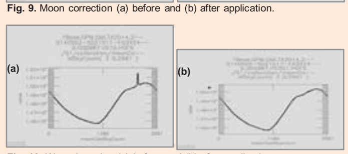


Fig. 10. Warm intrusion (a) before and (b) after application.

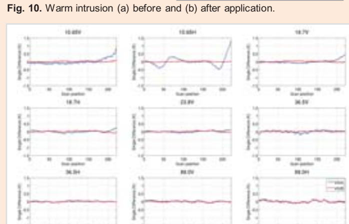
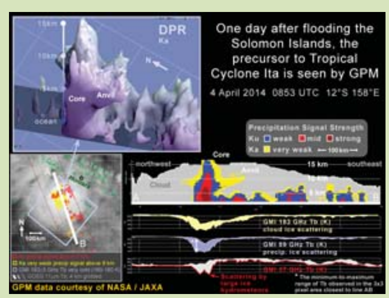
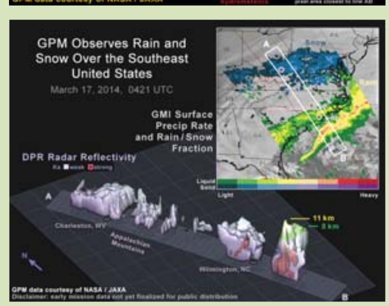


Fig. 11. Magnetic anomaly before correction (blue) and after correction (red).

5. Conclusion





The GPM data products are in good shape even at this early stage of the mission. The image over the Solomon Islands shows the advantage of the Ka radar, which provides information on the storm's "anvil", something that could not be seen with the TRMM Precipitation Radar. Even early snow retrieval is reasonable, as can be seen from the image on the left. Users are encouraged to retrieve and use the data—always keeping in mind the data caveats that the algorithm developers have provided. The early results are promising, exciting, and already show new insights not seen with TRMM. The new radar and radiometer frequencies are detecting features that would have been invisible to the TRMM satellite instruments. For additional information, please contact **Erich.F.Stocker@nasa.gov**